

B Lifetimes

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B Meeting

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Not on behalf of Lifetime Task Force

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How Do You Measure a Lifetime?

- Select a decay of particle of interest

- Estimate *flight distance* L

- Estimate boost $\beta\gamma$

- Use *decay time* $t \equiv L/\beta\gamma$ distribution to estimate *lifetime* τ_{signal}

- Account for

- Flight-distance dependent selection bias
 - Resolution
 - Backgrounds

- What can go wrong?

- Estimate of flight distance
 - Alignment, scale factor, vertex problems
 - Estimate of boost
 - p_T , $\cos\theta$, K-factor
 - L-dependent bias
 - SVT
 - Pattern Rec (HL)
 - σ_L
 - Resolution function
 - Non-gaussian tails
 - Background
 - Estimate of f_B
 - Decay time distribution of bkgd

Introduction



- Known Knowns
- Known Unknowns
- Unknown Unknowns

Known Knowns

- Measurements

- Semileptonic Lifetimes
- Exclusive Lifetimes
- Charm Lifetimes

- Studies

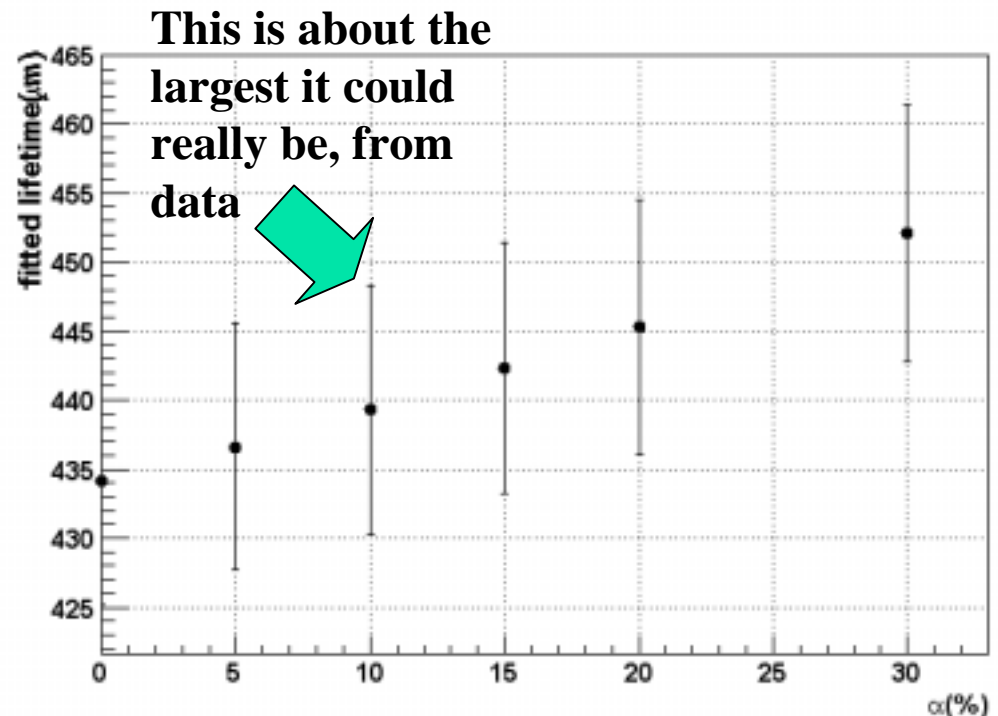
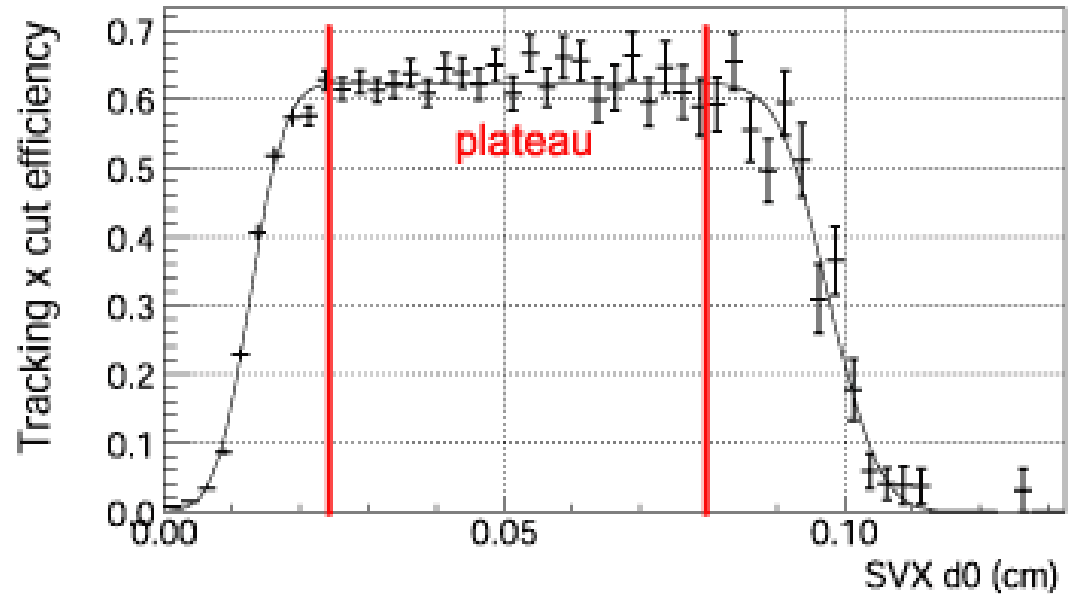
- Alignment
 - Bows
- SVT trigger bias

KK: Semileptonic Lifetimes

- Now using cuts very similar to Run I
 - In particular, use σ_{ct} instead of σ_{Lxy}
- 8 GeV $\mu + D^0$
 - $c\tau = 421 \pm 16 \mu\text{m}$
 - If use σ_{Lxy} cut
 - $c\tau = 486 \pm 16 \mu\text{m}$
- 4 GeV $m + SVT$
 - $c\tau = 434 \pm 9 \mu\text{m}$
- Mixture of B^0, B^+
 - MC predicts $495 \mu\text{m}$
- Cross check from Ilya K.
 - No smoking guns found
- $\mu + D^{*+}$ also low
 - More purely B^0
 - MC predicts $475 \mu\text{m}$
 - $c\tau \sim 420 \mu\text{m}$
- $\mu + D^+$ preliminarily (first results this week) very low
 - Also fairly pure B^0
 - $c\tau \sim 390 \mu\text{m}$

KK: SVT Studies

- Two studies done for lepton+D⁰
 - Require d₀ of tracks is entirely within plateau region
 - Vary “plateau” region slope, quantify effect on τ
- Both studies show negligible change in extracted lifetime
 - 0, +5 μm respectively



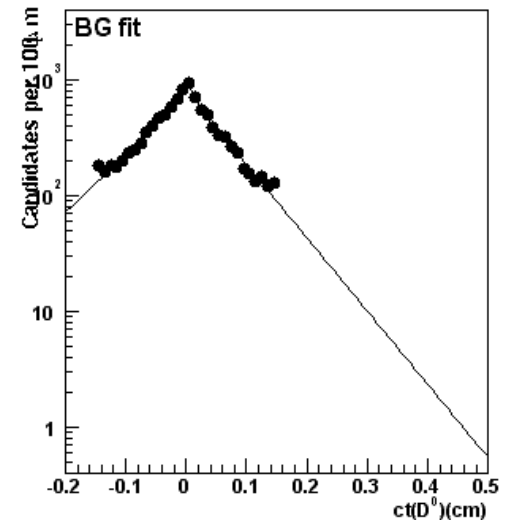
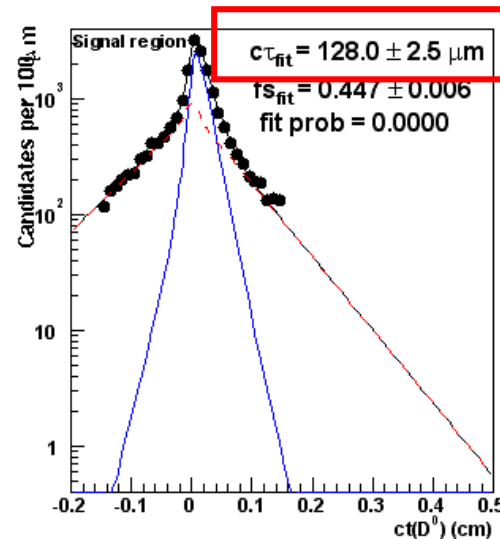
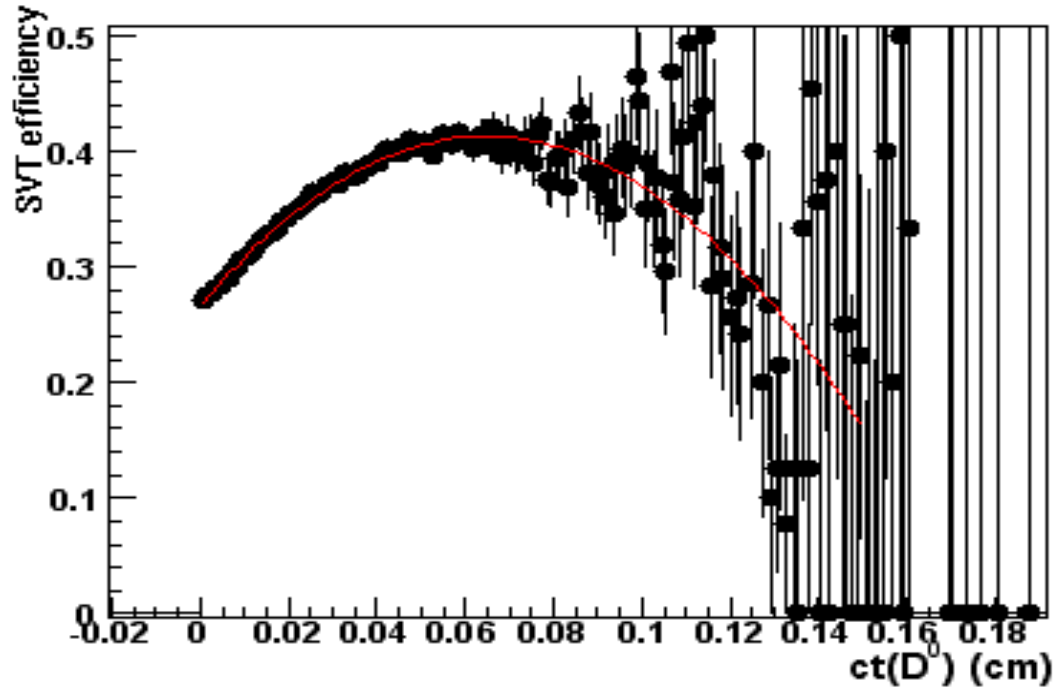
KK: Exclusive B Lifetimes

Mode	PDG	σ_{PDG}	Msmt	Error	Ratio	Ratio Err.	Citation
B0 \rightarrow Psi K*	462	5	425	29	0.92	0.06	Blessed
B0 \rightarrow Psi K0	462	5	385	67	0.83	0.15	6387
B+ \rightarrow Psi K+	502	5	470	21	0.94	0.04	Blessed
B+ \rightarrow Psi K*	502	5	630	91	1.25	0.18	6387
Bs \rightarrow Psi Phi	452	21	379	60	0.84	0.14	Blessed
$\Lambda_b \rightarrow$ Psi Λ	368	26	366	68	0.99	0.20	Pre-blessed

■ CDF “Lifetime Scale Factor”: 0.93 ± 0.03

- Removed CDF Run I Msmts from PDG by hand
- Did not do anything fancy in calculating average ratio (no correlated systematic uncertainties, in particular)
- Cf. $\mu^+ D^0$ scale factor: 0.89 ± 0.02
- As will show, though, there are reasons to believe this may be coincidence

KK: Charm Lifetime



- Measure D^0 lifetime in μ^+D^0
 - Flight distance from μ^+D^0 vertex to D^0 vertex
 - SVT trigger introduces (fairly moderate) D^0 ct-dependent efficiency
 - Re-evaluate curve
 - Fit for D^0 lifetime
- Find 128 ± 3 mm
 - PDG: $123 \mu\text{m}$
 - MC indicates +2 mm bias from technical issue in ct efficiency function
- Can also measure D^+ , D_s^+ lifetimes this way
- *Seems to rule out global scale problem*

KK: Alignment

- Konstantin Bow and Alignment Tests
 - Compare three versions of the alignment
 - Compare default to
 - All ladders bowed in and out 50 μm
 - All ladders at 50 μm higher and lower radius than recorded
- Bow effects all under 3 μm in $c\tau$
- Alignment version variation
 - 18 μm between “no alignment” and best available at the time
 - 5 between first alignment and best alignment
 - “No alignment” had large scale factor
 - Assigned 5 μm total
- Ronan SVX alignment
 - Performed I+D+ lifetime of D+ with
 - Standard alignment
 - Ronan's SVX alignment
 - Difference $\sim 10 \mu\text{m}$
- *Seems to rule out large alignment/bow effects*
- But now there are new alignments of I SL, COT
 - Need to re-evaluate

KK: Run Dependence

- Konstantine found pre- and post-shutdown difference

- B⁺

- Pre-shutdown: 470 ± 18
- Post-shutdown: 522 ± 26
- (487 ± 15)

- B⁰

- Pre-shutdown: 427 ± 25
- Post-shutdown: 490 ± 32
- (451 ± 20)

- Exclusive lifetime scale factor becomes

- 0.97 ± 0.03

- No pre/post difference in semileptonic decays

- Pre-shutdown: 434 ± 9

- Post-shutdown: 421 ± 11

Known Unknowns

- Semileptonic Analysis Effects

- Background description
- K-factors

- CDF-wide

- Detector Effects
 - Length scale
 - Resolution functions
- Reconstruction
 - HL tracks
 - CTVMFT
 - Environment / L_{inst}

KU: Semileptonic Analysis

■ Backgrounds

- Fake D^0 background seems well-controlled
 - Well-defined sidebands
 - Correct $c\tau$
- D^0+L background
 - L either fake, or not from B SL decay
 - No accounting
 - But comparison of many MC distributions looks OK
- Background lifetimes have somewhat counterintuitive behaviors
 - Often longer than B , and multi-component
 - No positive evidence of mismodeling, though

■ K-factors

- Run I K factors different for 8 GeV leptons than Run II (avg. value different by 3%, shapes fairly similar)
 - Not known why
- Use of Run I K factors seems to yield correct answer (11% shift)
 - But both Satoru and Ilya independently generated the Run II K-factors and largely agreed
 - Ilya sees 5% shift in lifetime result for using $\langle K \rangle$ instead of convoluting K-factor
- p_T dependence of K-factors is fairly small
 - m_{ID0} dependence unknown to me

KU: HL Tracking

- Psi+V0 analyses (Psi Ks, Psi Λ) see large lifetime effects due to HL V0 tracks

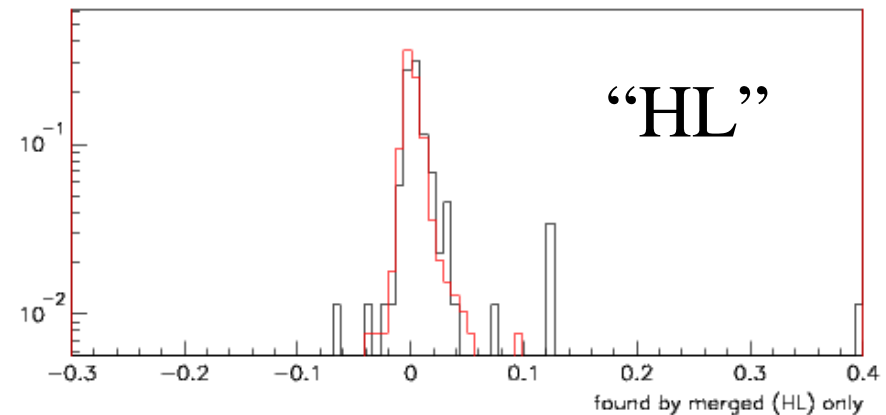
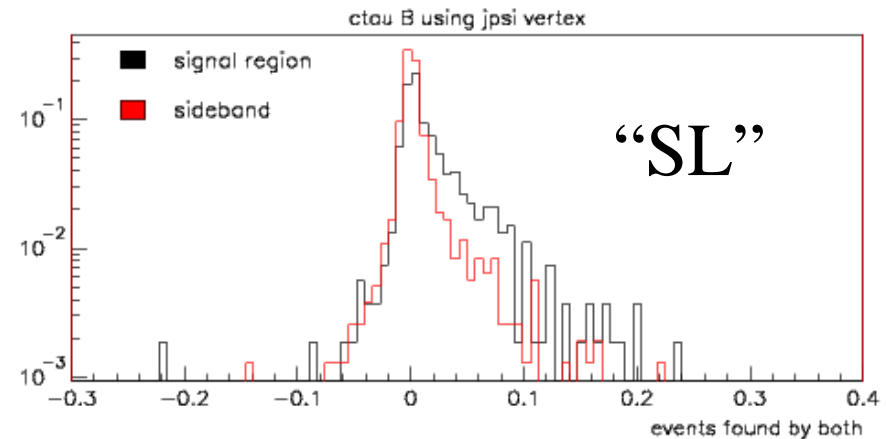
- B's w/ HL tracks have lifetimes almost consistent with 0

- This behavior is not reproduced in MC!

- Probably due to environment

- Belief

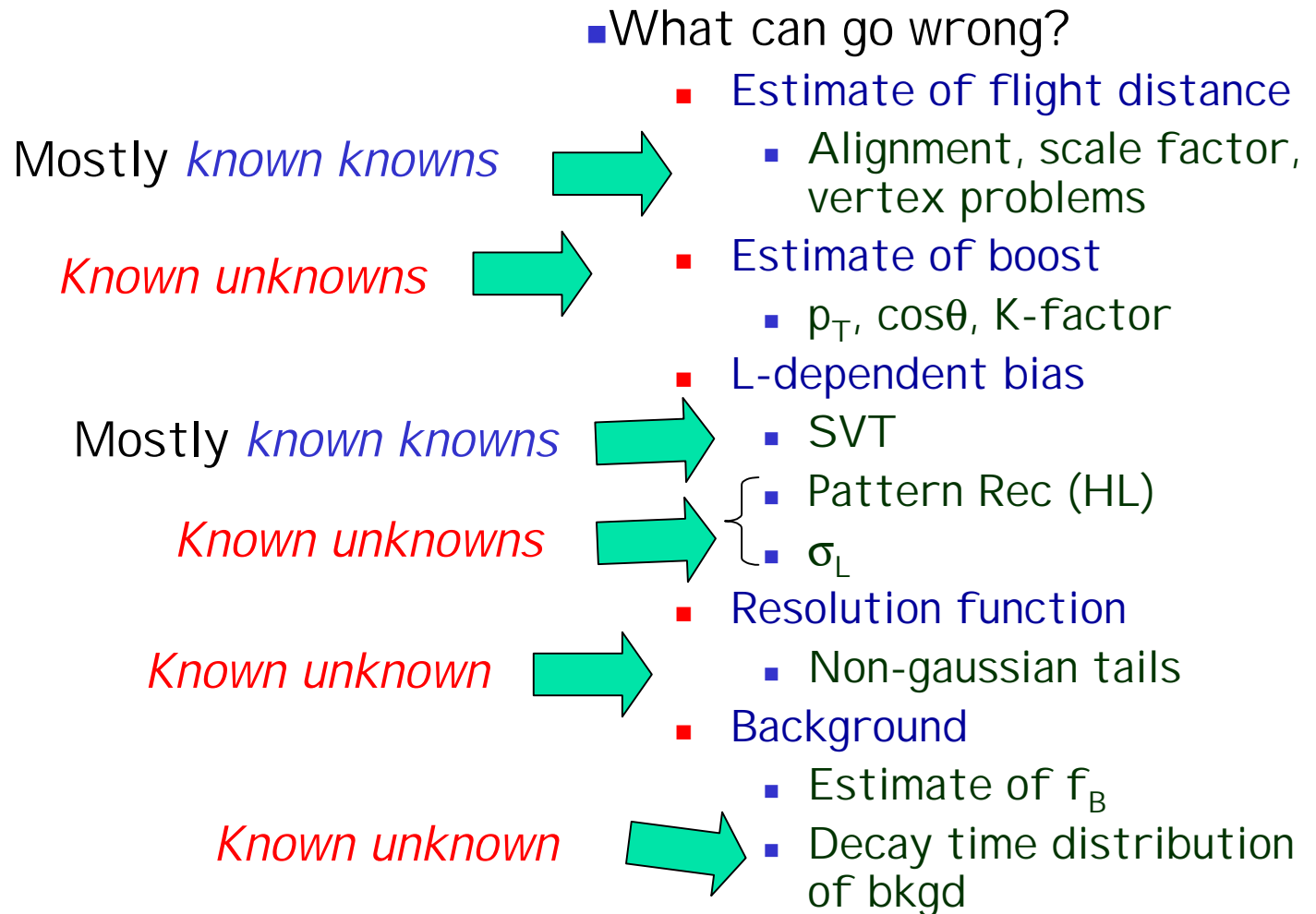
- HL bias towards beamspot biases Psi-flight-distance selection efficiency through pointing constraint
- The actual V0 COT tracks are not moving the vertex itself around!
- Not confirmed in detail yet



Unknown Unknowns

“Each year we discover a few more of these unknown unknowns”

Scorecard



My Own Take

- Semileptonics present big problem
 - Headed for 8σ w/ post-shutdown data
 - SVT/alignment not likely to be problem
 - p_T spectrum of B's also seems unlikely culprit
 - Vertex position not likely to be culprit
- Many, many things to check
 - Need to prioritize in order to maximize odds of finding it quickly
 - K factors, HL, large σ_{Lxy} , non-B background
 - p_T spectrum dependence, $K(m_{ID0})$, XFT, SVX hit requirements, EVTGEN/QQ
- CDF-wide
 - D^0 lifetime is spot on
 - Including all data, exclusive lifetimes seem OK
 - Hard to make large CDF-wide effects
 - E.g. alignment $\sim 10 \mu m$
 - Personally doubt that problem is CDF-wide
- We have to get this right
 - Production train leaving the station
- To ponder:
 - Would this have been sent out if PDG did not already tell us the right answer?

(One Unendorsed Plan)

■ Semileptonic Analysis

- Understand RunI /RunII K-factor disagreement
- Remeasure with HL removed (reprocessing)
- Explore lifetime of large σ_{Lxy} events
- Look at $e+D^0$ (bkgds)
- Measure D^+ lifetime in $l+D^+$
- Quantification of p_T spectrum dependence
- Should we use m_{lD^0} -dependent K-factors?
- New XFT configuration (1-miss/2-miss)
- Check EVTGEN/QQ difference

■ CDF-wide Checklist

- High-statistics D^{*+} analysis
 - $D \rightarrow K\pi$, $D \rightarrow K_S \pi\pi$
 - $c\tau$ as function of ϕ , SVX barrel, run range, L_{inst} , XFT, etc
 - Hard to know correct answer, but easy to spot variations with above
- Alignment tests
 - Pre- and post- COT re-alignment
 - Different requirements on Si hits on tracks
- Does phantom layer or final fitter matter?
- Measmnt. of beampipe radius
- Resolution function: $\Upsilon \rightarrow \mu\mu$